Application of Kernel-Based Modules on Fleet Resource Management System to Improve Service Quality for Freight Carriers with Lower Costs

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ABSTRACT

The freight transport plays a vital role in supporting economic activities. However, freight transport currently faces many challenging problems, including traffic congestion, negative environmental impact, and high energy consumption etc. There are over 5,000 freight carriers in Taiwan, but there are only below 15%, limited on insufficient funds, can invest fleet resource management system (FRMS) to provide higher levels of service with lower costs. In Taiwan, Institute of Transportation (IOT), Ministry of Transportation and Communications has proposed a series of comprehensive plans for the development of deployment of ITS/CVO. In this paper, we propose a kernel-based concept for FRMS to improve service quality for freight carriers with lower system costs. From the system analysis, the kernel-based modules on FRMS design customized functions, including orders management, fleet operation(e.g. vehicle routing, driver scheduling), fleet resources(e.g. vehicle, driver and equipment) management, cargo tracking and dynamic navigation for different types of vehicle. We also present the development experience and the practical evaluation of the FRMS by IOT form 2007. The results of system evaluation show the system can reduce 10.95% fuel costs for the freight carrier and reduce the 10.95% CO_2 emissions.

1. INTRODUCTION

In 2002, Ministry of Transportation and Communication (MOTC) has proposed the development architecture and promotion strategy for Commercial Vehicle Operation (CVO) [1] in Taiwan. As a result, since 2003, in accordance with sequentially focusing on the gravel truck and hazard substance vehicle that have relative higher traffic accident rate and serious injuries, MOTC also has made use of AVL technology to develop the fleet management system to improve the transportation safety via integrated

fleet monitoring; on the other hand, Ministry of Economic Affairs has utilized scientific projects to subsidize large-scale freight carriers to develop their electronicalization and mobilization systems. However, among those 5,638 freight carriers in Taiwan, only 14.14% of them (large-sized companies) possessed better capability of establishing the commercial fleet management system, and the rest of them (85.86%) are medium and small-sized companies which have restricted mostly by their fleet scale or limited funding; thus, they are incapable of using the fleet management system that may conform to their company operating characteristics. In order to effectively make improvement in service quality and lower the operating cost for those medium and small-sized freight carriers, since 2007, Institute of Transportation (IOT) has cooperated with the research team of Chung Hua University to develop the fleet resource management system (FRMS) for commercial vehicle in accordance with the kernel-based module concept.

2. Characteristics of Taiwanese Freight Carriers

In Taiwan, freight carriers can be divided into three types: Trucking Carrier, Container Trucking Carrier and Fixed-route Trucking Carrier; in addition, if take the amount of US$ 1 million capital as the threshold of the medium and small-sized enterprises, then the ratio of medium and small-sized enterprise in those 3 aforesaid business types can be readjusted as shown in Figure 1: among which, the total number of trucking carriers is 4912, and the ratio of medium and small-sized enterprises is 86.13%; the number of container trucking carriers totaled 702, and the ratio of medium and small-sized enterprises is 85.73%; in addition, the number of fixed-route trucking carriers totaled 25, most fixed-route trucking carriers are large-sized companies, and the ratio of medium and small-sized enterprises is only 36.00%; thus, overall speaking, the ratio of companies that classified as medium and small-sized enterprises is 85.86% among those Taiwanese freight carriers.

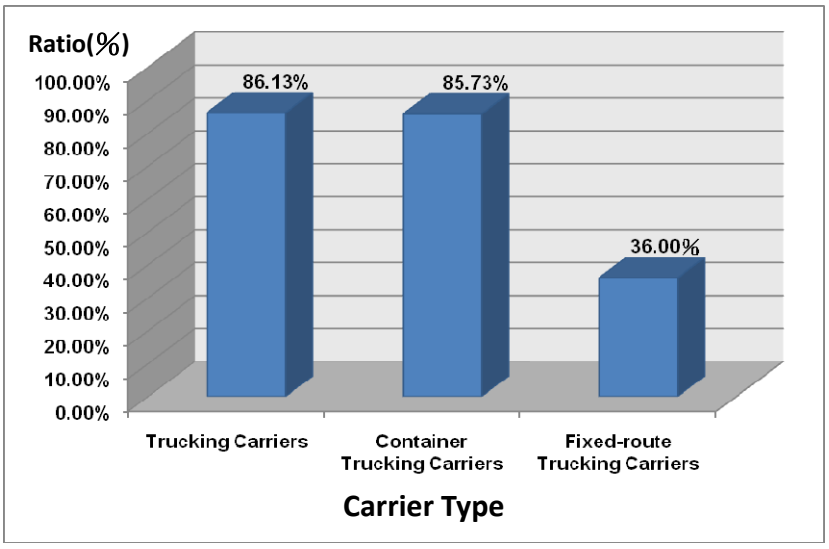

Figure 1. Ratio of Medium and Small-sized Companies among Different Types of Freight Carriers in Taiwan [4]

3. Development of CVO in Taiwan

Development of CVO in Taiwan can be divided into 2 segments: the public sector leading system, and the system that developed by private IT companies in accordance with their own business benefits. Among which, as for the segment of public sector, MOTC has demonstrated the project of fleet management system for gravel truck in 2003, which hoped to make use the Automatic Vehicle Location (AVL) and the collection and communication of driving status monitoring information to improve the effectiveness of fleet management and the operating efficiency for the transportation industry. After considering these 4 major units, including vehicle, information center, gravel trucking operator and motor vehicles office and policy authority, 3 major subsystems were drafted, such as the system management, fleet management and information management. Among which, the subsystem of system management contained 2 modules: the user information management module and the organization information management module; the fleet management subsystem (FMS) included 5 module, such as the routing management module, scheduling management module, loading management module, speed management module, and emergency rescue module; and the management information subsystem (MIS) contained 7 modules, including the personnel management module, customer management module, sales management module, maintenance management module, statistical analysis module, transportation document management module and financial management module. [2] Moreover, in 2004, MOTC has conducted the research project on the hazard substance management system in accordance with the corrosive, toxic and flammable nature of those hazard substances that may easily result in serious safety issue during the transporting process; in addition, such management system has integrated with the fleet monitoring, fleet dispatching management, electronic documentation, material safety database technologies, and it achieved a significant managing and controlling effectiveness for the process of transporting the hazard substance. [3]

As for the private IT companies, there are about 20 firms have developed their own CVO systems, and most of them were adopted AVL technology to provide users with the vehicle monitoring function which allowed company supervisors to effectively control the driving behaviors for their drivers. However, only a few IT companies that integrated the fleet management system to implement their vehicle dispatching process, and due to the carrying cost of such system is more than US$ 50,000, thus the freight carriers didn't show a significant acceptance of such system. Thus, in the future, how MOTC integrate the resources from academic research institutes, with aiming at those trucking carrier and container trucking carrier that have a higher ratio of being medium/small-sized companies, to develop a fleet resource management system with a carrying cost less than US$ 100 and suitable for medium/small-sized freight carriers is one of the key issues in this paper.

4. FRMS System architecture

In accordance with the function architecture planned by ERTICO (European Road Transport Telematics Implementation Coordination Organization), this paper took vehicles and equipment (such as trailer) and driver in the fleet resources as the scope of developing the fleet resource management system (FRMS). Since 2007, within a period of one year, the researcher has undertook the review process for related domestic and foreign fleet resource management systems, conducted the interview process of those benchmarks for freight carriers, and implemented the survey process of their demands; in addition, after analyzed all collected data and information, the researcher has determined the principles of FRMS for those medium/small-sized freight carriers, including:

(1) System's order processing and freight tracking functions that can only proceed from the integral angle of the fleet resource management and provide related simple management function without considering the order input format or user interface as the key points of development.

(2) System provided basic AVL functions that related to the fleet resource management without considering the planning of monitoring interface or previous monitoring record as the key points of development; in addition, if they need to use the AVL function, then they still need to discuss with experienced manufacturers for their assistance in building the AVL platform.

(3) Except for providing the automatic scheduling function, this system still need to provide the manual fine tuning function and the evaluation function of manual input program.

(4) System needs to provide the self-management function of electronic map in order to provide freight carriers with setting the vehicle driving conditions from the electronic map database according to the characteristic of vehicle models for their own fleet.

(5) System will be used to lower the related costs that freight carriers adopted it; thus, the lowest cost using is the principle of making use of this system.

According to the aforesaid principles of the system demand. The FRMS contains 6 following kernel-based modules, such as the basic information management module, order management module, vehicle dispatching module, vehicle routing module, AVL and navigation module, report preparation and performance indicator analysis; in addition, each freight carrier can flexibly choose the necessary module function in accordance with its practical demand to make up its own system; at the same time, they can self-develop individual and unique module function according to its actual requirement. With considering the confidentiality of customer information for freight carriers, FRMS's basic information management, order management, vehicle dispatching, vehicle routing and report preparation module will be the operating modes of local area network (LAN) version; however, due to the vehicle monitoring module that needs to integrate with he electronic map, and then it can be concurrently considered with individual difference and the necessity of integrating real-time road/traffic information for freight carriers to the vehicle routing; thus, it is designed to connect the electronic map of National e-Traffic Center via Internet, and such operating process can be connected by API, then display the map interface in this

system. During the overall operating process, all data and information will be stored in the database server which designated in the local area network (LAN); in terms of its interface development, the development of interface using, electronic map using and information security consideration will be carefully considered to be the most suitable system for their demand, and made use of the kernel-based module with bearing the minimum cost, and the planning of its kernel-based module architecture is shown as in Figure 2.

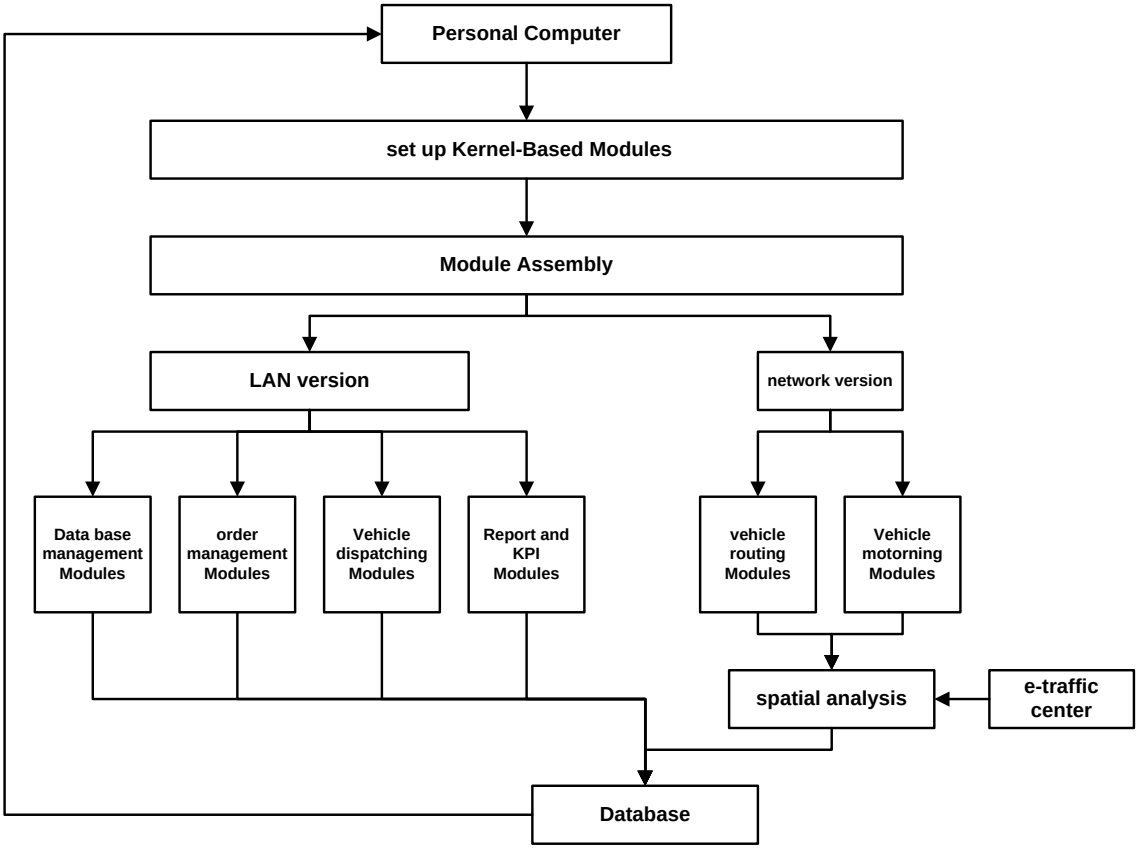

Figure 2. Kernel-based Module Architecture Diagram of FRMS for CVO [5]

5. System Function Planning

In accordance with the current fleet resource management operation status for the modern freight carriers, the FRMS has planned the module and database that belonged to every operating procedure as shown in Figure 3. The planned kernel-based module planning is shown in Table 1, including 2 business types that contained 9 modules, and each module function is also shown in Table 2. In addition, FRMS will be still considered the difference between the environments whether the freight carriers have equipped with AVL on-board unit or not, and that will be divided into the basic and advanced types as shown in Figure 4. Among which, the basic type functions will be all functions that applicable to all freight carriers; but, the vehicle monitoring module is only applicable to the freight carriers that have equipped with GPS on-board unit in order to real-time monitor their outside driving vehicle.

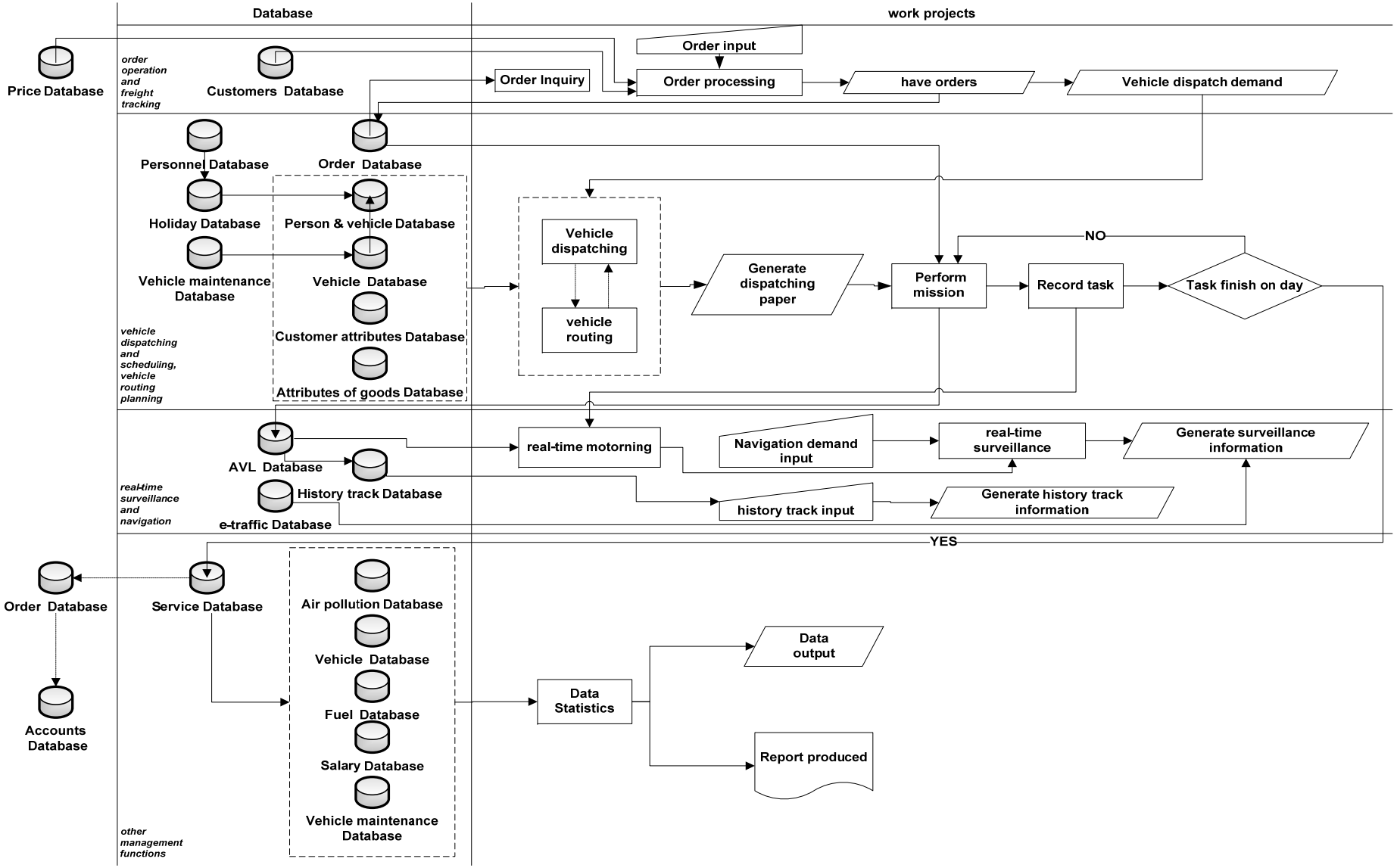

Figure 3. Relationship Diagram between FRMS and Each Operating Procedure [5]

Table 1. Roundtable of Kernel-based Module Development [4]

Modules / Category	order management Module	vehicle routing Module	Vehicle dispatching Module	Data base management Module	AVL and navigation Module	report preparation and KPI Module
Trucking Carrier	●	●	●	●	●	●
Container Trucking Carrier	●	●	●			

Table 2. Roundtable of Kernel-based Module Function [5]

Modules / Category	order management Module	vehicle routing Module	Vehicle dispatching Module	Data base management Module	AVL and navigation Module	report preparation and KPI Module
Trucking Carrier	● order management	● vehicle route guidance ● Return resistance of road	● Mission assigned ● Return Mission	● Guest management ● drivers management ● vehicle management ● company management	● Vehicle real-time surveillance ● query history track	● drivers management statements ● vehicle management statements ● Fuel Consumption Analysis statements ● tire management statements ● KPI Indicators Analysis
Container Trucking Carrier				● Guest management ● drivers management ● vehicle management ● company management ● grillage management		

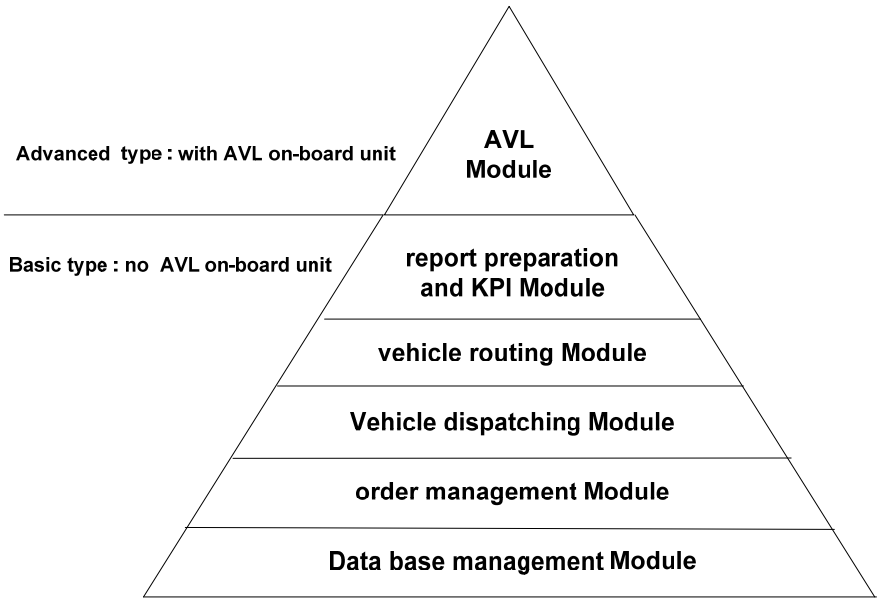

Figure 4. Hierarchical Structure Diagram of Kernel-based Module [5]

6. System Application

Related FRMS development operations have completed in 2008, and its demonstrative system has been built in 2 freight carriers and completed the test trial operation. It is expected to continuously assist another 2 IT companies that equipped with AVL technology in establishing FRMS; in addition, one container trucking carrier, Company A is hereby proposed as the demonstration of establishing such system and its testing result will be described as follows.

Currently, Company A has a fleet which consisted of 18-tone ~ 35-tone trailers without AVL system, and about 100 trailers. Its major clients are those hige-technology companies in Hsinchu Science Industrial Park, and the number of orders is probably 80 per day, which is a typical medium/small-sized container trucking carrier in Taiwan. At this moment, Company A is still adopted manual operation and its working procedures are shown as in Figure 5.

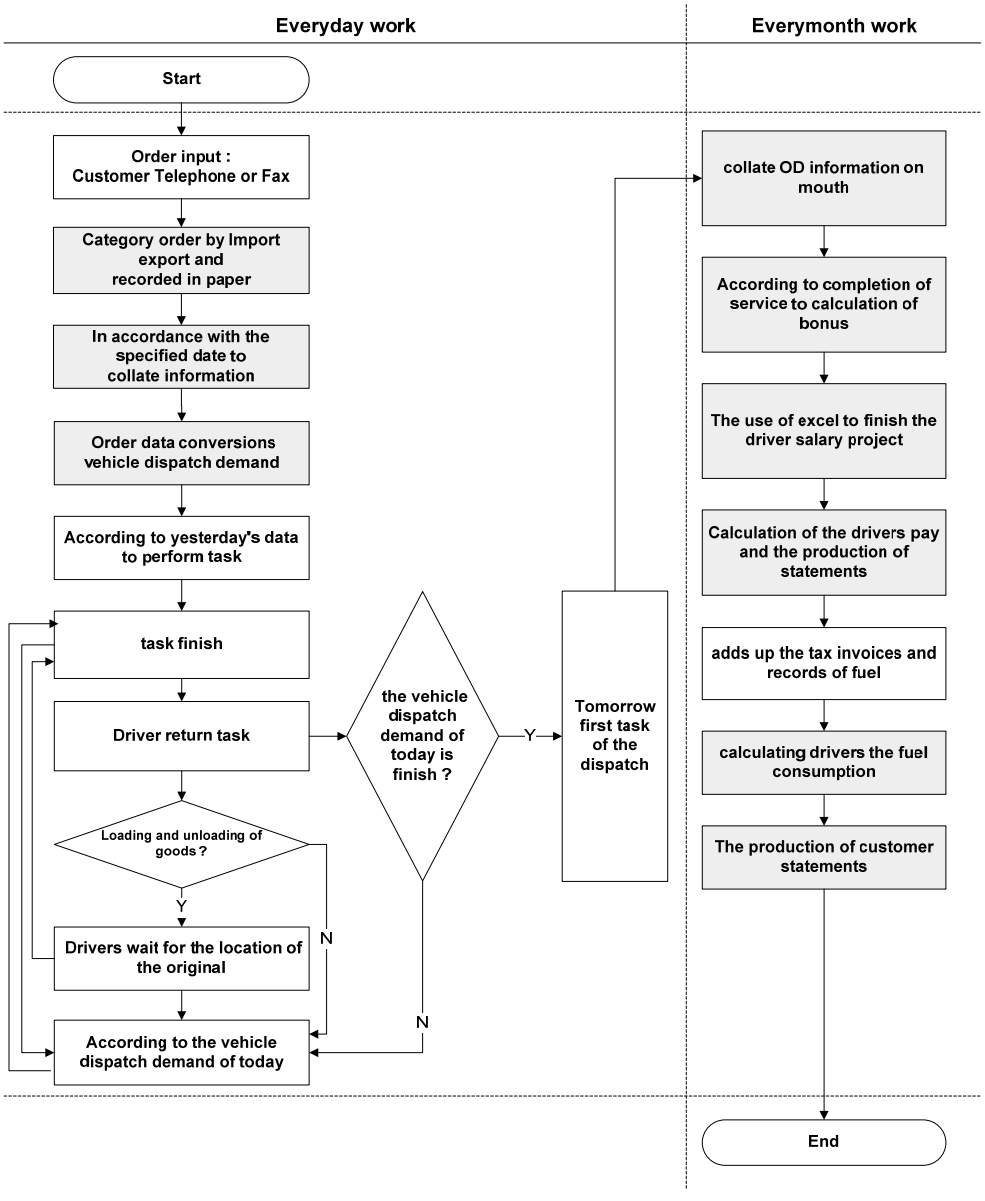

Figure 5. Current Operating Status of Company A [5]

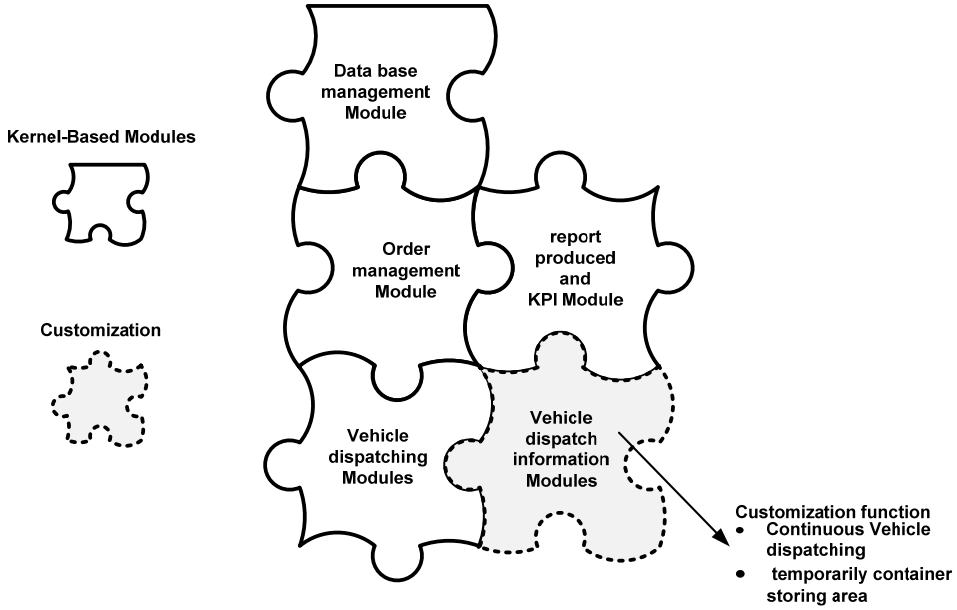

Figure 6. FRMS Assembly Diagram in Company A [5]

After conducted the actual on-line test for such system, and the result is shown as in Table 3. It found that, after Company A implemented FRMS, the empty-vehicle mileage can be saved 19.89% averagely for each trip/run and the gasoline consumption can be saved about NT$ 101,800 for each month with an improved margin of 10.95%, which revealed the implementation of FRMS can be significantly improve the dispatching efficiency for Company A. In terms of improving the efficiency for the operating time, the procedure improvement and time statistics are shown as in Figure 7, and it discovered that the implementation of FRMS can shorten the information processing time from the original 44.9 hours to 8.4 hours per month with a saving ratio of 81%.

Table 3. Comparison of Saving Values Before and After System Implementation [5]

Item	Before FRMS	After FRMS	improve values (improve ratio)
Average empty-vehicle mileage (empty mileage / trips)	**9.95**	**7.97**	**1.98(19.89%)**
Empty-vehicle mileage rate (%)	**16.54**	**14.31**	**2.23(13.48%)**
CO_2 emissions (tone / month)	**125.63**	**111.87**	**13.76(10.95%)**
fuel costs (million / month)	**0.93**	**0.83**	**0.10(10.95%)**

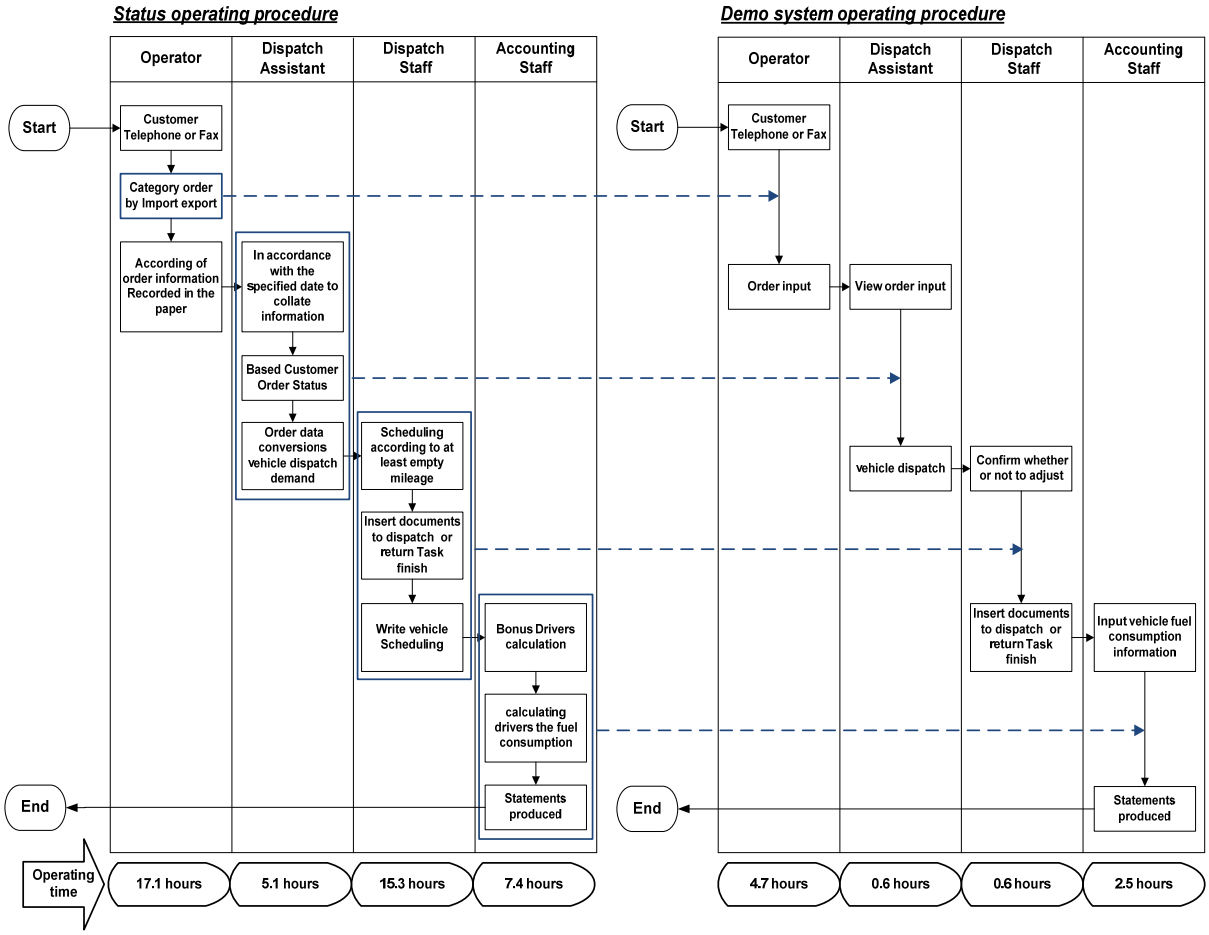

Figure 7. Comparison of Saving Time of Operation Procedure Before and After FRMS System Implementation [5]

7. CONCLUSIONS

In recent years, the CVO project in the ITS field has been greatly promoted in Taiwan. This paper is then considered the current status and environment of that there are more than 85% medium/small-sized freight carriers in Taiwan, and they are more likely incapable of establishing the fleet resource management system; thus, through Institute of Transportation, Ministry of Transportation and Communication, to integrate with academic resources, and the completion of demand analysis process to develop a fleet resource management system with lower cost, which will cover the order processing, vehicle dispatching, salary calculation, customer payment requisition and each function of resource management for freight carriers. Practical trial has been completed in 2 demonstrate companies in 2008, and the researcher discovered that such practice can not only improve about 19.89% of vehicle using efficiency, but also lower the CO_2 emissions and gasoline consumption; in terms of operating efficiency, it can be even more saved about 81% operating time that will make a great improvement in operating efficiency for the freight carriers and advance their industrial competitiveness. In 2009, it will continuously transfer FRMS to another 2 IT companies that already

possessed AVL technology. Thus, the promotion of FRMS will still be continued through the existing resources from private sector in Taiwan.

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